AD-A208 751

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS NONE
2a SECURITY CLASSIFICATION AUTHORITY N/A	3 UNLIMITED
2b DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) None	5 MONITORING ORGANIZATION REPORT NUMBER(S) None
6a NAME OF PERFORMING ORGANIZATION Naval Coastal Systems Center 6b OFFICE SYMBOL (If applicable) Code5150	7a NAME OF MONITORING ORGANIZATION Naval Sea Systems Command, PMS407D
6c ADDRESS (City, State, and ZIP Code) Panama City, FL 32407-5000	7b ADDRESS (City, State, and ZIP Code) Washington, DC 20362
8a NAME OF FUNDING/SPONSORING ORGANIZATION Chief of Naval Operations 8b OFFICE SYMBOL (If applicable) OP-374	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A
8c ADDRESS (City, State, and ZIP Code) The Pentagon Washington DC 20350	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO 65130D PROJECT NO TASK NO WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

WIRE SWEEP MONITORING EQUIPMENT (WSME) TEST REPORT

12 PERSONAL AUTHOR(S)

13a TYPE OF REPORT	13b TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Test & Evaluation	FROM ______ TO ______	88/12	57

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	
13	10		Mechanical Minesweeping

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

(U) Describes the Wire Sweep Monitoring Equipment (WSME) in use by the Royal Navy (UK) and tests conducted off San Diego to determine the potential benefits to the U.S. Navy from using this equipment. The report concludes that control of mechanical sweep wire is more precise when using tensions as a performance guide than when using ship speed. It also concludes that the triple tensiometer arrangement aboard U.S MSOs is preferred over the single tensiometer used by WSME.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a NAME OF RESPONSIBLE INDIVIDUAL Harry Dietz	22b TELEPHONE (Include Area Code) (202) 692-3915	22c OFFICE SYMBOL PMS407D31

DD Form 1473, JUN 86 Previous editions are obsolete SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

055

WIRE SWEEP MONITORING EQUIPMENT

(WSME)

TEST REPORT

DECEMBER 1988

A1

PREPARED FOR:
NAVAL SEA SYSTEMS COMMAND
PMS407D31

PREPARED BY:
NAVAL COASTAL SYSTEMS CENTER
PANAMA CITY, FL 32407

ENCLOSURE(1)

CONTENTS

Page No.

1.0 EXECUTIVE SUMMARY 1

2.0 INTRODUCTION 3

2.1 BACKGROUND 3

2.2 CONCEPT OF OPERATIONS 3

2.3 HARDWARE DESCRIPTION 4

2.3.1 Major Components 4

2.3.1.1 Tensiometer Wire Measuring Beam (TWMB) . . 4
2.3.1.2 Main Electronics Unit 7
2.3.1.3 Sweep Monitor Console (SMC) 8

2.3.2 Ancillary Components 10

2.3.2.1 Stowage Locker 10
2.3.2.2 Restraining Pendants 10
2.3.2.3 Calibration Bar and Locker 10
2.3.2.4 Connecting Cables 10

3.0 TEST PURPOSE AND OBJECTIVES 11

3.1 PURPOSE 11

3.2 TEST OBJECTIVE 11

3.2.1 Original Test Objectives 11

3.2.2 Test Limitations 12

3.2.2.1 Speed Constraints 12
3.2.2.2 Speed Control 12
3.2.2.3 Fouled Depressor 12
3.2.2.4 Operating Area 13

3.2.3 Revised Test Objectives 13

4.0 GENERAL TEST INFORMATION 14

4.1 TEST SITE/PLATFORM 14

4.2 TEST TEAM 14

CONTENTS - (Continued)

Page No.

4.3 TEST PERSONNEL RESPONSIBILITIES 15

4.3.1 Naval Sea Systems Command 15

4.3.1.1 Project Manager 15

4.3.2 Naval Coastal Systems Center 15

4.3.2.1 Project Engineer 15
4.3.2.2 Test Director 15
4.3.2.3 Mechanical Technician 16
4.3.2.4 Civilian Safety Coordinator 16

4.3.3 BAJ Limited 16

4.3.3.1 BAJ Representatives 16

4.3.4 USS PLUCK 16

4.4 TEST SCHEDULE 17

5.0 CONDUCT OF THE TEST 18

5.1 TEST EVENTS 18

5.2 DATA ANALYSIS 21

5.2.1 Depth Recorder Data 21

5.2.2 Tension Data 26

6.0 TEST RESULTS AND DISCUSSION 27

7.0 CONCLUSIONS 45

8.0 RECOMMENDATIONS 47

APPENDIX A - DETAILED TEST EVENTS A-1

ILLUSTRATIONS

Figure No.		Page No.
2.1	Wire Sweep Monitoring Equipment System	5
2.2	Tensiometer Wire Measuring Beam	6
6.1	Sweep Tension = 3.55 Tonnes	28
6.2	Sweep Speed = 5.8 Knots	29
6.3	Sweep Speed = 6.2 Knots	30
6.4	Sweep Tension = 3.1 and 3.2 Tonnes	31
6.5	Sweep Tension = 3.45 Tonnes	32
6.6	Sweep Tension = 2.9 Tonnes	33
6.7	Sweep Tension = 3.45 Tonnes	34
6.8	Speed and Tension Comparison	36
6.9	Sweep Tension = 3.1 Tonnes	37
6.10	Sweep Speed = 6.0 Knots	38
6.11	Sweep Tension = 2.9 Tonnes	39
6.12	Sweep Speed = 6.0 Knots	40
6.13	Sweep Tension = 3.3 Tonnes	41
6.14	Sweep Speed = 8.2 Knots	42
6.15	Tension = 2.9 Tonnes	44

TABLES

Table No.		Page No.
5.1	Cutter/Depth Recorder Spacing in Fathoms	19
5.2	WSME Test Events	22
7.1	Maximum Sweep Depth	47

1.0 EXECUTIVE SUMMARY

Naval Sea Systems Command (COMNAVSEASYSCOM) (PMS 407D) tasked Naval Coastal Systems Center (NAVCOASTSYSCEN), to evaluate the Wire Sweep Monitoring Equipment (WSME) which is currently in production by BAJ LTD for use on the UK Royal Navy River Class Fleet Minesweepers.

The US Navy is building two new classes of mine countermeasure ships (MCM-1 and MHC-51) and the usefulness of WSME is being evaluated for applicability to these new ships. The WSME system offers the potential for improvement in performance to both in-service and developmental mechanical minesweeping equipments.

The objectives of this test were to:

1. Evaluate the concept of sweeping by tension using WSME: Verify, using Size 1 equipment towed from an MSO class ship, that a flat mechanical minesweeping profile could be achieved and maintained by towing at a constant tension.

2. Compare sweeping by tension to the conventional sweeping by ship speed and define in terms of hog/sag the advantages and disadvantages of each method.

Results of the test showed that:

1. The uncertainty in sweep wire profile is greater when ship's speed vice sweep wire tension is used as a towing guide.

2. WSME does not measure and display sufficient tension information.

3. MSO speed adjustments may not be fine enough to maintain target tension in the sweep wire.

4. Sensitivity to sweep wire problems is reduced when using tension as a towing guide.

Recommendations are as follows:

1. To minimize sweep depth uncertainty, MSOs should use tension rather than speed as a towing guide for Oropesa type mechanical sweep systems.

2. When towing by tension, drastic speed changes should be noted and peak tensions monitored on a regular basis.

3. WSME should not replace existing tensiometers on MSOs.

4. Future testing of WSME should be limited to variable depth sweeps such as IDMS.

2.0 INTRODUCTION

2.1 BACKGROUND

NAVCOASTSYSCEN was tasked by NAVSEASYSCOM (PMS 407D) to evaluate the Wire Sweep Monitoring Equipment (WSME) which is currently in production by BAJ LTD for use on the UK Royal Navy River Class Fleet Minesweepers. The WSME system offers the potential for improvements in performance of both in-service and developmental mechanical minesweeping gear with minimal effort in shipboard installation.

2.2 CONCEPT OF OPERATIONS

The WSME is designed for use aboard mine countermeasure platforms. The purpose of the system is to improve countermeasure effectiveness during mechanical sweeping of moored mines.

The system works on the principle that for a particular sweep configuration (whether Team or Single Ship) there is an optimum speed through the water at which the most critical part of the system (the sweep wire(s)) will be flat and horizontal. At this speed, the hydrodynamic forces balance the weight of the sweep hardware; the sweep will have a certain value of drag and this will give rise to a specific tension in the towing wire at the ship.

By monitoring the tension, WSME enables the ship's speed to be adjusted to maintain the specific wire tension necessary to achieve a flat sweep.

2.3 HARDWARE DESCRIPTION

The system consists of a single accurate strain gauge tensiometer, a main electronics unit, and a sweep monitoring console (see Figure 2.1). The tensiometer, which is clamped onto the mechanical sweep/tow cable, measures the strain (tensile force) placed on the wire by the mechanical minesweeping equipment. The measurements are then transmitted to the sweep monitoring console via the main electronics unit, where they are displayed on a digital indicator. Aboard UK minesweepers the measurements are used to determine ship speed at the established tow cable length required to achieve a flat sweep profile. Additionally, for team deep sweeping tow cable length is monitored and displayed by the WSME thereby allowing shipboard personnel to adjust cable length in conjunction with the fathometer to maintain the sweep at a fixed seabed clearance.

2.3.1 Major Components

2.3.1.1 Tensiometer Wire Measuring Beam (TWMB). The tension and wire measuring sensors (Figure 2.2) takes the form of a stainless steel beam fitted with three pulleys. These pulleys are staggered so that the tow wire or sweep wire is deflected when the beam is clamped in place on the wire. The deflection of the tow/sweep wire induces a bending moment in the beam which is

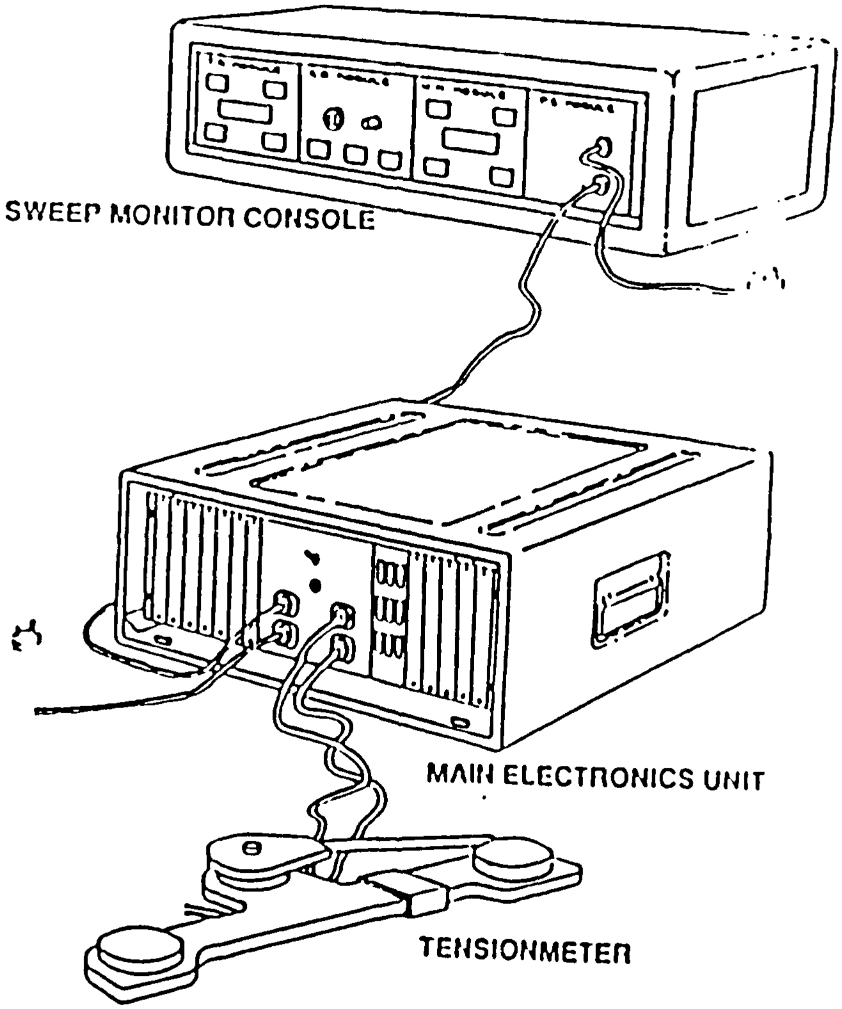


FIGURE 2.1. WIRE SWEEP MONITORING EQUIPMENT SYSTEM

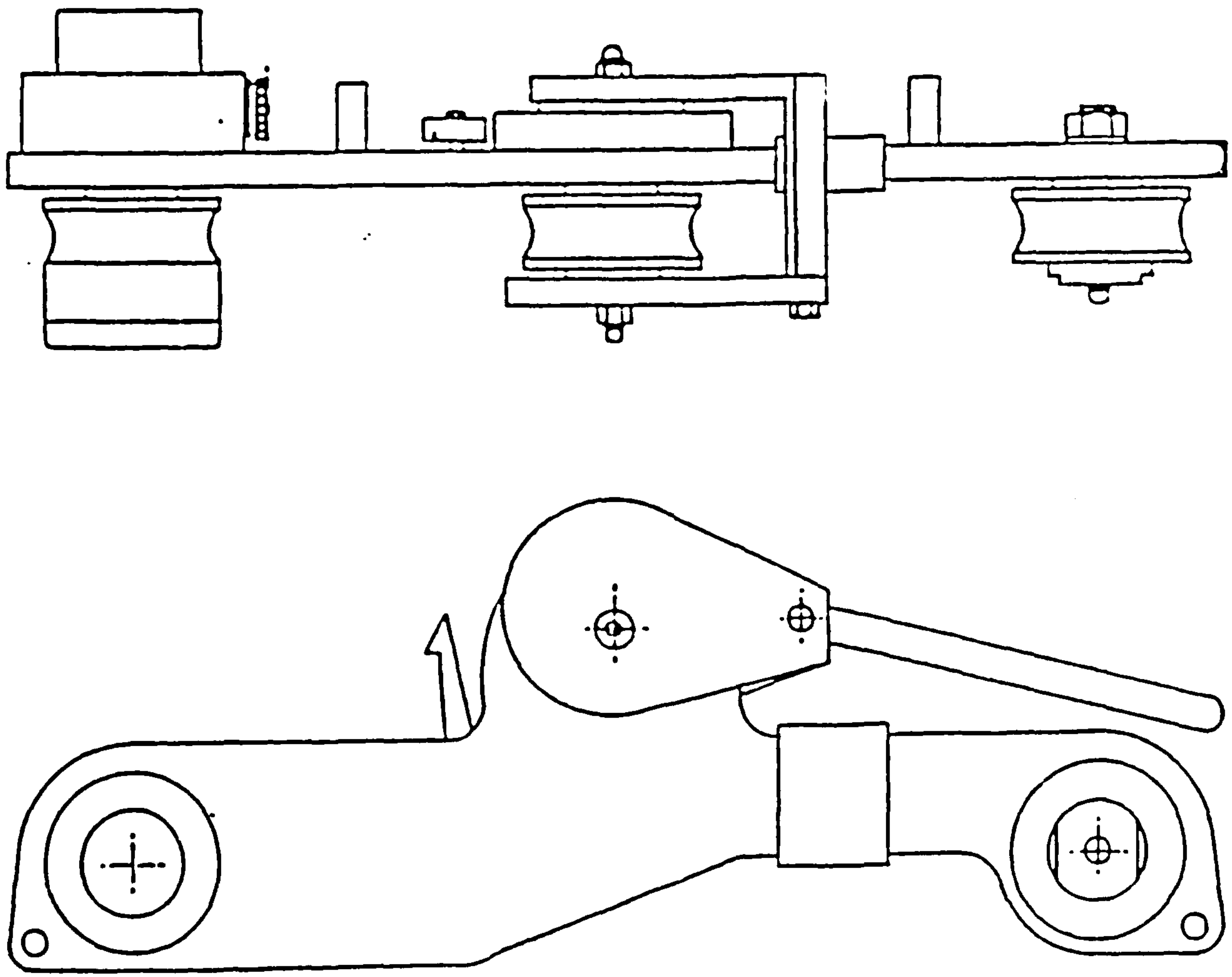


FIGURE 2.2. TENSIOMETER WIRE MEASURING BEAM

proportional to the wire tension. Strain gauges bonded to the surface of the beam are used to measure this load. The output from the gauges is connected to a bridge circuit and processing electronics within the Main Electronics Unit (MEU).

The central pulley is located on a cam connected to the release lever. With the lever in the open position, the beam can be fitted around the wire with the wire passing between the three pulley wheels. Closing the release lever lowers the center wheel onto the wire thereby clamping the unit in place and causing the required wire deflection.

The unit is restrained from moving fore and aft on the wire by two wire rope pendants shackled to the ship's deck, allowing wire to be heaved or veered through the beam. An optical encoder, enclosed in the aftermost pulley wheel, allows the number of pulley revolutions, and hence the amount of wire veered, to be calculated. The number of pulley revolutions is a function of the tension and the direction of the wire. The MEU compensates for these factors when calculating the wire veered.

When the tensiometer beam is not in use it is stowed in a specially built locker along with the signal cables and restraining pendants.

2.3.1.2 Main Electronics Unit. The principal function of the MEU is to take the strain gauge and encoder signals from the measuring beam and convert them to suitable forms for displaying. This is carried out in the following manner.

The strain gauge analog signal is first amplified and then passed through an analog to digital converter. The digitized signal is processed to provide peak and mean tension values which are sent to the display unit.

The pulses from the wire measuring encoder are used to calculate (and update) the length of wire veered and then to predict the sweep depth for team deep sweeping. The sweep depth value undergoes further processing in order to produce the equivalent echo sounder reading for team deep sweeps. These two parameters, the length of wire veered and the equivalent echo sounder reading, are then sent to the display unit.

The front cover of the MEU can be removed to gain access to the thumbwheel switches that set the various datum values for the system. Once these have been set the MEU does not need to be manned and consequently can be sited at any convenient position in the ship.

2.3.1.3 Sweep Monitor Console (SMC). The SMC displays the four parameters calculated by the MEU, namely, mean tension, peak tension of the displayed mean, wire veered, and equivalent echo sounder reading.

Mean tension is a running average of the strain gauge output and eliminates the fluctuation in tension that is caused by ship motion. Operationally the ship's speed is adjusted so that the displayed mean tension corresponds to the figure known to give a flat sweep profile. Peak tension gives an indication of the maximum load in the tow wire. For example, it can be used to monitor the dynamic loads in the system during heaving/veering or maneuvers.

The SMC is fitted with an alarm which is triggered if either the peak or mean tensions exceed the overload values previously set in the MEU. The choice of these overload values depends upon the type of sweep system deployed, the type of ship, and the sea state.

The amount of tow/sweep wire veered, as measured by the encoder, is displayed directly. The SMC is alarm triggered if at any stage the wire is heaved in beyond a preset minimum value.

Adjacent to the wire veered display is the Echo Sounder Equivalent Reading. This parameter is generated by adding the selected seabed clearance to the predicted sweep depth and applying corrections relating to the datum of the ship's echo sounder and the position from which the wire veered is measured. The resultant, which can be displayed in units of meters or fathoms, is a value for comparison with the ship's echo sounder reading during team sweeping evolutions. When the two numbers match, the sweep is at the selected seabed clearance. Any difference between the two values means that wire must be heaved/veered to adjust the sweep altitude.

It is envisioned that the SMC will normally be mounted in a closed environment. For the SMC to function to its full capability it must be clearly visible to the winch controller during team sweeping.

2.3.2 Ancillary Components

2.3.2.1 Stowage Locker. A stainless steel temporary stowage locker is provided with the equipment for stowing the TWMB with its cables and restraining pendant, during operational periods. The locker is designed to be permanently fixed in a convenient position on the sweep deck.

2.3.2.2 Restraining Pendants. To prevent the TWMB from moving fore and aft when the wire is heaved or veered through it, a pair of restraining pendants are employed. These shackle to the end of the beam and to suitable anchoring points on the sweep deck and winch.

2.3.2.3 Calibration Bar and Locker. To check the calibration of the tensiometer beam, a high tensile strain resisting steel bar is provided. This is designed to be fitted across the pulleys, in place of the tow wire, and apply a fixed load to the beam. If the correct test load value is not displayed on the SMC then the tensiometer beam is no longer within calibration and requires resetting. The calibration bar is provided with a specially built locker and would normally be stowed in a convenient compartment close to the sweep deck, with the on-board spares for example.

2.3.2.4 Connecting Cables. The system is supplied with a complete set of cables to link the TWMB to the MEU and the MEU to the SMC. These cables can either be built in as fixed ship's wiring runs or installed very quickly at a later stage. The latter case is important if the system is being fitted to an auxiliary ship/craft of opportunity.

3.0 TEST PURPOSE AND OBJECTIVES

3.1 PURPOSE

The purpose of this test was to evaluate the WSME and to make a comparison with conventional US sweep control techniques.

3.2 TEST OBJECTIVE

3.2.1 Original Test Objectives

The proposed objectives of this test were to:

a. Evaluate the concept of sweeping by tension using WSME: Verify, using Size 1 equipment towed from an MSO class ship, that a flat mechanical minesweeping profile could be achieved and maintained by towing at a constant tension.

b. Compare sweeping by tension to the conventional method of sweeping by ship's speed and define in terms of hog and sag the advantages and disadvantages of each method.

3.2.2 Test Limitations

3.2.2.1 Speed Constraints. The USS PLUCK was not always able to tow at speeds recommended in Fleet Tactical MCM publications. Speeds necessary for flat profile sweeps could, therefore, not be obtained using this test platform. During the first three days of testing, speeds of 8.5 knots were reached; however, during the remainder of the test period the maximum speed attained was approximately 7.5 knots in following seas and winds. Since reciprocal course runs were required at the same speeds, maximum speeds were reduced to 6.0 - 6.5 knots when towing against the seas and winds. In addition, speed problems prohibited repetition of the faster runs later on in the test period.

3.2.2.2 Speed Control. Ship's speed was controlled by adjustments to pitch. The finest adjustment was 1/4 foot of pitch which often resulted in speed changes over 1 knot and tension changes of up to 0.3 tonnes (1 tonne = ~ 2204 lbs). Changes of this magnitude were unacceptable and made it very difficult to maintain a constant speed or tension throughout the run.

3.2.2.3 Fouled Depressor. During several high speed and/or low radius turns, the depressor became fouled and did not ride properly. It was generally not possible to tell there was a problem until the days runs were completed and the gear was recovered or unless the fouled depressor surfaced. This occurrence altered the sweep profile and the data collected during runs with a fouled depressor was unsatisfactory.

3.2.2.4 Operating Area. Reciprocal course runs were not always possible as the USS PLUCK had a restricted area in which to conduct minesweeping operations. In addition, the area was shared with other Navy vessels conducting exercises, further limiting the operating area. During the test, course changes were made as close to 180 degrees as possible.

3.2.3 Revised Test Objectives

Due to the above mentioned test limitations, the original test objectives were modified as follows:

a. Evaluate the concept of sweeping by tension using WSME: Verify, using Size 1 equipment towed from an MSO class ship, that mechanical minesweeping profiles were repeatable when using tension as a towing guide.

b. Compare sweeping by tension to the conventional method of sweeping by ship speed in terms of profile repeatability (area of uncertainty).

4.0 GENERAL TEST INFORMATION

4.1 TEST SITE/PLATFORM

WSME tesing was conducted aboard the USS PLUCK off San Diego, CA in 200-1000 feet of water. Sea states ranged from 1 to 2 during the test.

4.2 TEST TEAM

Title	Telephone
Project Manager: COMNAVSEASYSCOM, Harry Deitz	AV 222-7790
Project Engineer: NAVCOASTSYSCEN, Gary Bohres	AV 436-4184
Test Director: NAVCOASTSYSCEN, Tracy Nye	AV 436-5110
Mechanical Technician/Civilian Safety Coordinator: NAVCOASTSYSCEN, Marvin Beasley	AV 436-5067
CSO MINEGRUONE, CDR Lee	AV 941-3904
CO USS PLUCK: LT Harrison	619-524-6922
MCM Officer USS PLUCK: LTJG Seivertson	691-524-6922
Safety Officer USS PLUCK: LT Edwards	691-524-6922
BAJ Representative: Jeff Moreton, Dale Jefferies	011-44-934-822251

4.3 TEST PERSONNEL RESPONSIBILITIES

4.3.1 Naval Sea Systems Command

4.3.1.1 Project Manager. Naval Sea Systems Command (PMS 407D) was responsible for the overall management and direction of the WSME program.

4.3.2 Naval Coastal Systems Center

4.3.2.1 Project Engineer. The Project Engineer was responsible for the management and direction of the WSME program at NAVCOASTSYSCEN. He is also responsible for:

a. Coordination and dissemination of documentation concerning the test.

b. Publication of the final test report.

c. Recommendation of further testing.

4.3.2.2 Test Director. The Test Director was responsible for the direction and coordination of the WSME test series. The Test Director conducted daily test operations briefings, directed the day-to-day test events, provided guidance to ensure that the testing was conducted in accordance with the test plan, and ensured that the test proceeded in a timely, progressive manner. The Test Director was also responsible for the safety of all civilian personnel involved in the testing. The Test Director ensured that the daily safety briefings were conducted before any testing was initiated.

4.3.2.3 Mechanical Technician. The Mechanical Technician ensured that all equipment was staged and shipped as required.

4.3.2.4 Civilian Safety Coordinator. The Safety Coordinator conducted daily safety briefings prior to the initiation of any testing. The Safety Coordinator was in attendance during all sweeping operations.

4.3.3 BAJ Limited

4.3.3.1 BAJ Representatives. BAJ personnel set up and operated WSME, collected data and performed data analysis.

4.3.4 USS PLUCK

The USS PLUCK conducted all sweeping operations. The safety officer was responsible for ensuring the sweeps were deployed and recovered in a safe manner.

4.4 TEST SCHEDULE

Test Day	Date	Event
1	8 Sep 88	Single "O" Sweep
2	13 Sep 88	Single "O" Sweep
3	14 Sep 88	Single "O" Sweep
4	15 Sep 88	Single "O" Sweep
5	16 Sep 88	Single "O" Sweep
6	17 Sep 88	Single "O" Sweep
7	19 Sep 88	Single "O" Sweep
8	20 Sep 88	Single "O" Sweep
9	21 Sep 88	Single "O" Sweep
10	22 Sep 88	Single "O" Sweep

5.0 CONDUCT OF THE TEST

5.1 TEST EVENTS

Due to speed limitations of the USS PLUCK, 150- and 200-fathom single Oropesa sweeps were deployed in lieu of the planned double Oropesa sweeps. It was determined that the higher drag of the double "O" sweeps would cause a further reduction in speed capabilities. This modification required changes in depressor wire scopes; however, changes in planned sweep wire tension and tow speed were unnecessary. The current towing speed tables in Fleet Tactical Publications do not distinguish between double and single "O" type sweeps; sweep wire tensions are measured independently and should be the same for both type sweeps. (The total tension for a double "O" will be nearly twice that of a single "O", but the tension of each sweep wire should be the same regardless of the type of sweep.)

As the "O" gear was streamed, depth recorders were placed along the sweep wire at intervals similar to standard cutter positions (Table 5.1). In order to optimize available test time, these positions were the same for all sweep scopes. By holding the positions constant, the sweep did not have to be recovered every time a scope change was called for. When scope was increased from 150 fathoms to 200 fathoms an additional depth recorder was added to the sweep wire. Upon completion of streaming, the WSME tension beam was connected to the starboard sweep wire.

TABLE 5.1. CUTTER/DEPTH RECORDER SPACING IN FATHOMS

(Measured From Outboard End of Sweep Wire)

Cutter/Depth Recorder	Spacing (Fathoms)
Depth Recorder 1	9
Depth Recorder 2	19
Cutter #1	31
Depth Recorder 3	44
Depth Recorder 4	59
Depth Recorder 5	76
Depth Recorder 6	95
Depth Recorder 7	117
Depth Recorder 8	141
Cutter #2	169
Depth Recorder 9	185

To adequately assess the hog and sag in a sweep wire profile, the depressor and the otter should be at the same depth. Therefore, the first runs of each sweep configuration were dedicated to establishing the correct depressor wire scope. Once these scopes had been set, they were used throughout the test. When the ship's power was reduced midway through the test period, the determined scope values were no longer applicable since both the otter and the depressor depth vary as a function of speed. Efforts to re-establish depressor scopes were minimized since it was not possible to maintain a consistent speed envelope.

It was planned that the first series of runs would consist of a control run into the wind at maximum ship speed. Then, the next two runs would be on a different heading than the control run; one at the control run speed and one at the control run tension. However, because of the speed and op area constraints (described in test limitations) this was not always possible. When it was realized that a particular heading, speed, or tension could not be achieved, new variables were targeted.

Each run was approximately 30 minutes long and was initiated after the speed indicator (or WSME readout) had stabilized.

At the completion of the days runs the sweep was recovered and the data stored in the depth recorders was recovered. The last 20 minutes of each run's depth readings were averaged and plotted as depth versus distance along sweep wire. Sweep profiles of runs at the same tension were compared as were profiles at the same speed.

The test scenario was conducted with 150- and 200-fathom sweeps with both 60- and 90-foot float pendants. Sweep configurations were tested along various headings on different days to determine repeatability in the data. Table 5.2 summarized the runs conducted during the test period.

5.2 DATA ANALYSIS

5.2.1 Depth Recorder Data

The depth recorders were set to take readings every 30 seconds. They were energized prior to being deployed, and on most tests days, the batteries had not been expended until after the recorders were recovered. The "on deck" depth values were compared and any deviations were incorporated in data reduction.

Twenty minutes of depth recorder information (40 data points) were extracted for each run that was conducted during the test. A statistical summary of these values was made and the mean values and variance calculated. Maximum and minimum values were also recorded providing information to judge the stability of the run.

Sweep profile curves were generated by plotting the mean values of the depth recorders against their position along the sweep wire. When comparing sweep profiles, the area between the shallowest and deepest profile was calculated and designated as the area of uncertainty.

TABLE 5.2. WSME TEST EVENTS

Run No. (Day-Run #)	Configuration: Wire Scope (Fath)	Configuration: Pend Length (Ft)	Configuration: Dep. Scope (Fath)	Tension (Tonnes): Actual	Tension (Tonnes): Target	Speed (Knots): Actual	Speed (Knots): Target	Heading	Comments
8-1	150	60	16	3.1	3.3		NA		Setting depressor scope.
13-1	150	60	10	3.3	3.5	8.5	NA		Setting depressor scope.
-2			10	2.9	3.0	8.0	NA		Setting depressor scope.
-3			10	2.2	2.5	7.0	NA		Setting depressor scope.
-4			13		3.5	8.5	-		Lost data file.
-5			13	2.9	3.0	7.7	-		Setting depressor scope.
-6			13	2.5	2.5	7.5	-		Depressor scope determined - 13 fathoms.
-7			13	3.2	3.5	8.2	-		
14-1	200	60	17	3.5	3.5	8.0	-		
-2			17	3.0	3.0	7.3	-		
-3			19	3.0	3.5	7.8	NA		Setting depressor scope.
-4			19	3.2	3.5	7.7	NA		Setting depressor scope determined to be 17 fathoms.
-5	150	60	13	3.3	3.5	8.0	-		
-6	150	60	13	3.35	-	8.2	8.2		
15-1	200	60	17	3.1	3.0	7.1		215°	

TABLE 5.2. WSME TEST EVENTS - (Continued)

Run No. (Day-Run #)	Configuration: Wire Scope (Fath)	Pend Length (Ft)	Dep. Scope (Fath)	Tension (Tonnes): Actual	Target	Speed (Knots): Actual	Target	Heading	Comments
-2			17	3.1	3.0	7.5		215^{o}	
-3			17	3.1		7.1	7.0	000	
-4			17	3.35	3.5	7.5		000	Tension varied 3.5 -3.31.
-5	150	60	13	3.6		7.9	8.0	100	Tension 3.9 - 3.5/speed stayed fairly constant.
16-1	150	90	26	3.5	3.5	7.0	NA	225	Setting depressor scope.
-2			26	2.6	3.0	6.1	NA	225	Setting depressor scope.
-3			23	3.3	3.5	7.0		225	
-4			23	2.8	3.0	6.5		038	Depressor fouled.
-5			20	3.45	3.5	7.1		047	Setting depressor scope - determined to be 22 fathoms.
17-1	200	90	26	3.3	3.5	7.0		240	Setting depressor scope.
-2			23	3.3	3.5	6.9		242	Depressor scope determined to be 23 fathoms.
-3	150	90	22	-	-	-	-		Aborted - Depressor fouled.
-4				3.4	3.5	7.0		060	
-5				2.9		7.0	7.0	251	

TABLE 5.2. WSME TEST EVENTS - (Continued)

Run No. (Day-Run #)	Configuration: Wire Scope (Fath)	Configuration: Pend Length (Ft)	Configuration: Dep. Scope (Fath)	Tension (Tonnes): Actual	Tension (Tonnes): Target	Speed (Knots): Actual	Speed (Knots): Target	Heading	Comments
-6				2.9	3.4	6.7		251	
-7				3.45	3.5	7.3		060	
19-1	200	90	23	3.6	3.6	6.2		252	
-2			23	3.55	3.5	6.3		165	
-3			23	3.2		6.2	6.0	165	
-4			23	3.55	3.5	6.8		347	
-5			23	2.9		5.8	6.0	347	
-6	150	90	22	2.9	3.0	5.8		073	
-7	150	90	22	3.6	3.5	7.0		073	
20-1	200	90	23	3.1		5.8	6.0	228	
-2			23	3.2	3.2	5.9	6.0	228	
-3			23	3.2	3.2	6.0		040	
-4			23	3.7		6.0	6.0	045	Depressor fouled.
-5	150	90	22	3.2	3.0	6.2		198	Could not maintain 3.0.
-6				2.9	3.0	5.9		198	Could not maintain 3.0. Depressor fouled.
-7				-	-	-	-	-	High tension on depressor wire. Aborted run.

TABLE 5.2. WSME TEST EVENTS - (Continued)

Run No. (Day-Run #)	Configuration: Wire Scope (Fath)	Configuration: Pend Length (Ft)	Configuration: Dep. Scope (Fath)	Tension (Tonnes): Actual	Tension (Tonnes): Target	Speed (Knots): Actual	Speed (Knots): Target	Heading	Comments
-8				2.8	2.9	5.5		018	
21-1	200	60	17	2.2	3.0	4.0		248	Control run (ship was not able to go faster).
-2				2.2	2.2	4.2		060	
-3				1.8		4.0	4.0	045	
-4									OPS canceled because of engine problems.
22-1	200	60	17	3.1	3.0	5.5		237	
-2				3.4		6.3	8.0	237	
-3				3.1		6.0	6.3	57	
-4				3.3	3.1	6.0		57	
-5	150	60	13	3.3	3.3	6.0		235°	
-6				-	-	-	-	-	Aborted. #2 engine down.
-7				2.9	2.9	5.8		238°	
-8				3.3		6.1	6.0	055	
-9				2.9	2.9	5.5		055	

5.2.2 Tension Data

WSME tension values were recorded every 15 seconds during a run. These were averaged values calculated from 5 samples (one every 3 seconds). Approximately 80 samples (20 minutes worth of data) of the average data were again averaged to establish an overall mean value for the run. In addition, the maximum values and the minimum values of the 5 samples were averaged establishing mean maximum and mean minimum values for the 20-minute period. Tension values were compared to the NCSC calibrated electronic tensiometer to determine the accuracy of the WSME. The NCSC tensiometer also provided tension readings for the depressor wire.

6.0 TEST RESULTS AND DISCUSSION

Selected profiles of the 200-fathom/90-foot float pendant sweep configuration are shown in Figures 6.1 through 6.4. The profiles in Figure 6.1 were obtained by towing at a prescribed tension of 3.55 to 3.6 tonnes. As course changes were made, the ship's EM log indicated speed changes of around half a knot. The area of uncertainty of the combined sweep profiles is approximately 24 square yards. Figures 6.2 and 6.3 are profiles obtained when sweeping by speed. The area of uncertainty is increased to 90 square yards and 41 square yards respectively.

Figure 6.4 shows profiles of three sweeps; two towed at 3.2 tonnes and one towed at 3.1 tonnes. The two sweeps towed at 3.2 tonnes showed repeatable profiles and the profile of the sweep towed 3.1 tonnes had an overall greater depth than the higher tension runs as would be expected.

Figures 6.5 through 6.7 are profiles of the 150-fathom/90-foot float pendant configuration. Figure 6.5 profiles three sweeps which were towed by speed. Although the maximum speed differences were only a tenth of a knot, sweep profiles were dramatically different. Profiles followed tension curves with the highest tension showing the shallowest profile and the lowest tension having the deepest profile. Figures 6.6 and 6.7 are profiles of sweeps towed by tension. These sweeps show more repeatable profiles than the sweeps given in Figure 6.5.

FIGURE 6.1

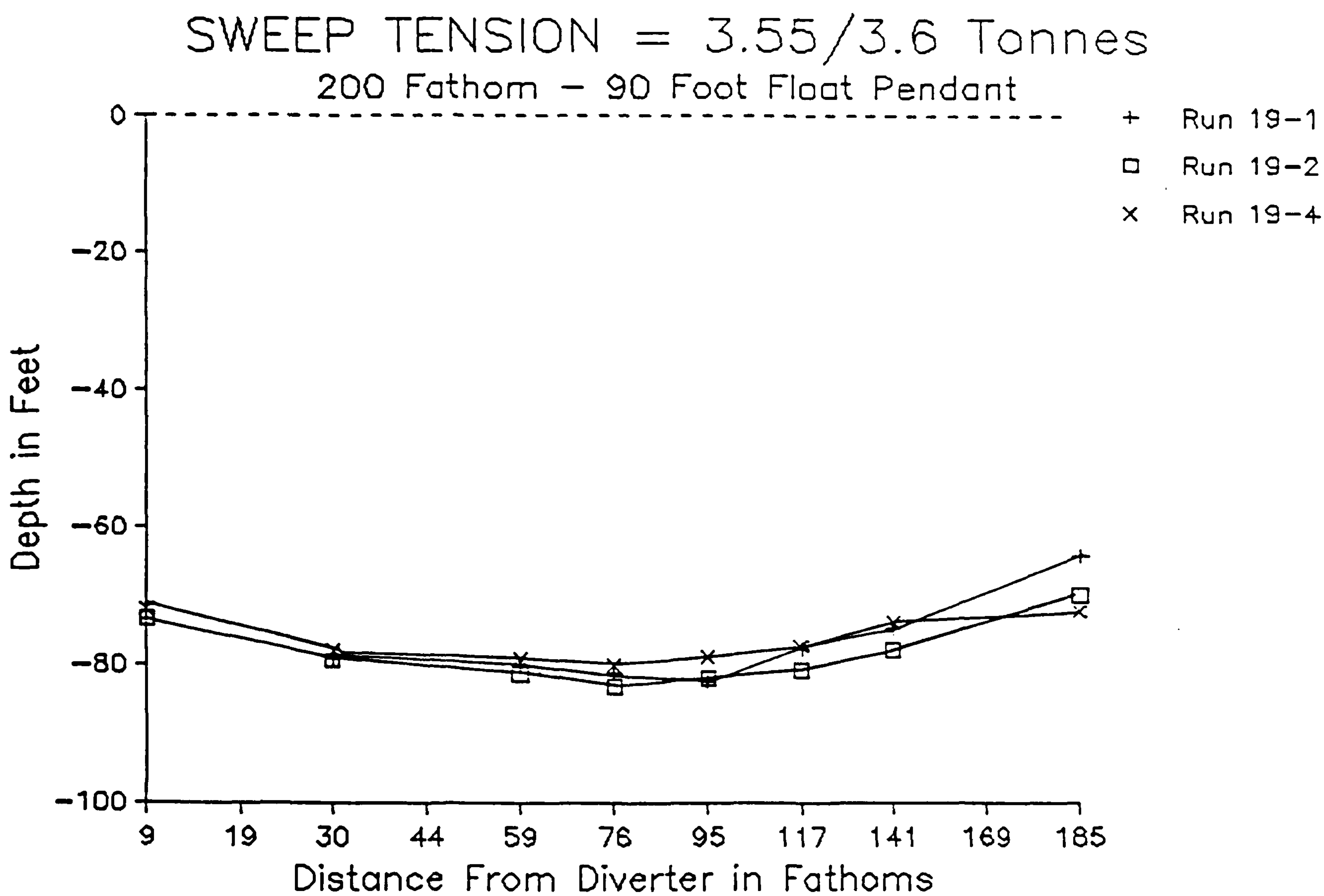

SWEEP TENSION = 3.55/3.6 Tonnes
200 Fathom - 90 Foot Float Pendant
Run 19-1
Run 19-2
Run 19-4
0
-20
-40
-60
-80
-100
Depth in Feet
9
19
30
44
59
76
95
117
141
169
185
Distance From Diverter in Fathoms

FIGURE 6.2

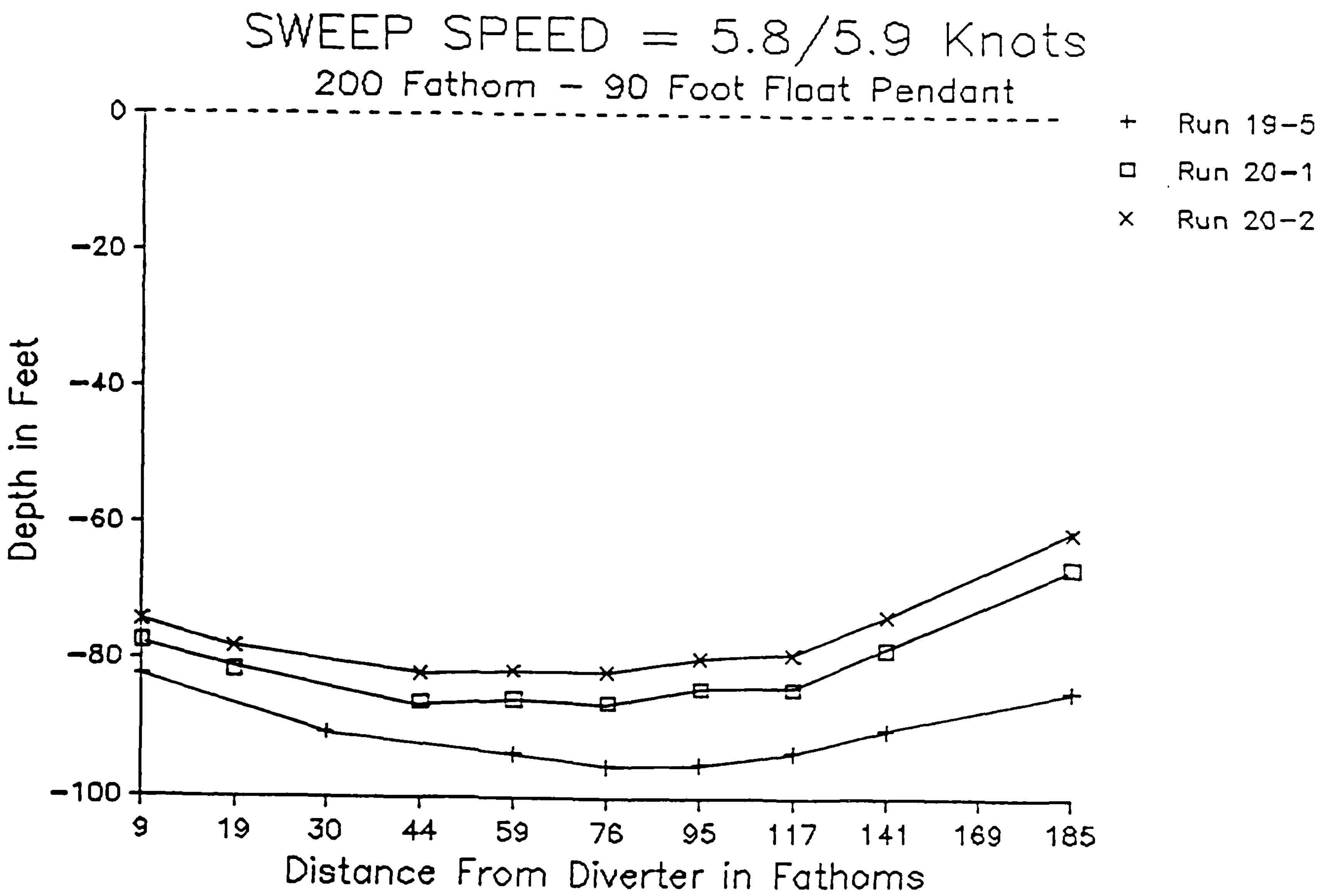

SWEEP SPEED = 5.8/5.9 Knots
200 Fathom - 90 Foot Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
30
44
59
76
95
117
141
169
185
Distance From Diverter in Fathoms
Run 19-5
Run 20-1
Run 20-2

FIGURE 6.3

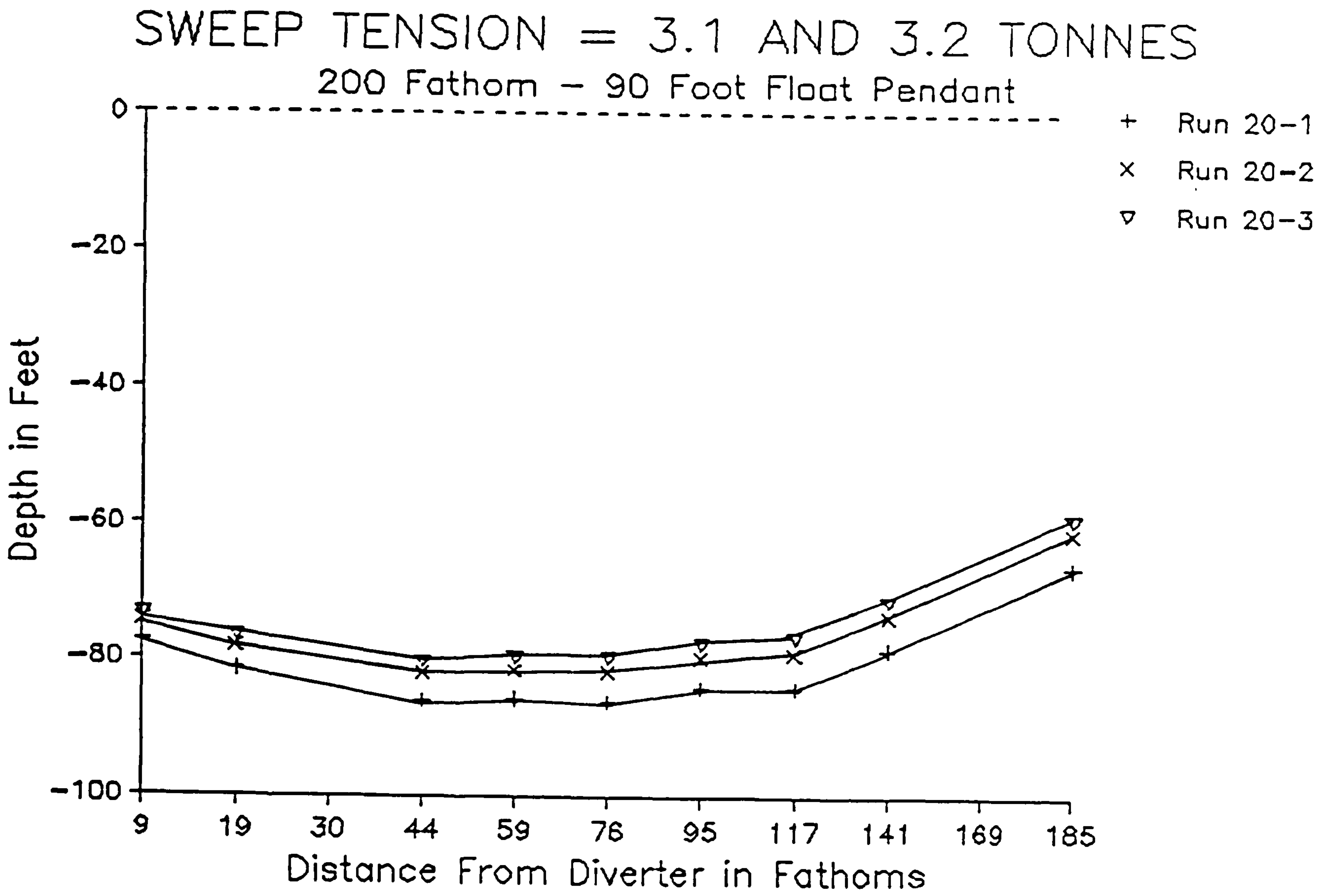

SWEEP TENSION = 3.1 AND 3.2 TONNES
200 Fathom – 90 Foot Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
30
44
59
76
95
117
141
169
185
Distance From Diverter in Fathoms
+ Run 20-1
× Run 20-2
▽ Run 20-3

FIGURE 6.4

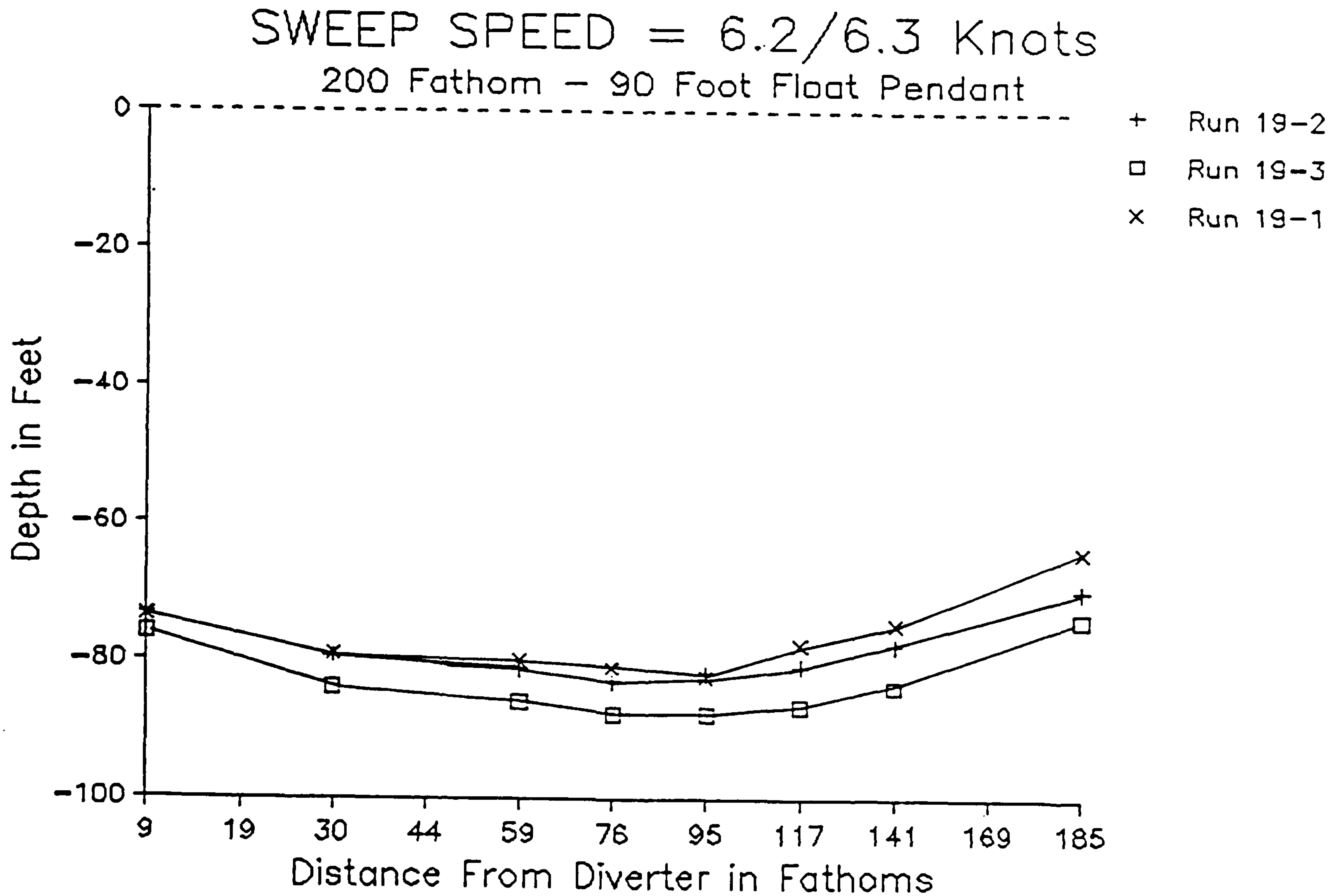

SWEEP SPEED = 6.2/6.3 Knots
200 Fathom - 90 Foot Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
Distance From Diverter in Fathoms
9
19
30
44
59
76
95
117
141
169
185
Run 19-2
Run 19-3
Run 19-1

FIGURE 6.5

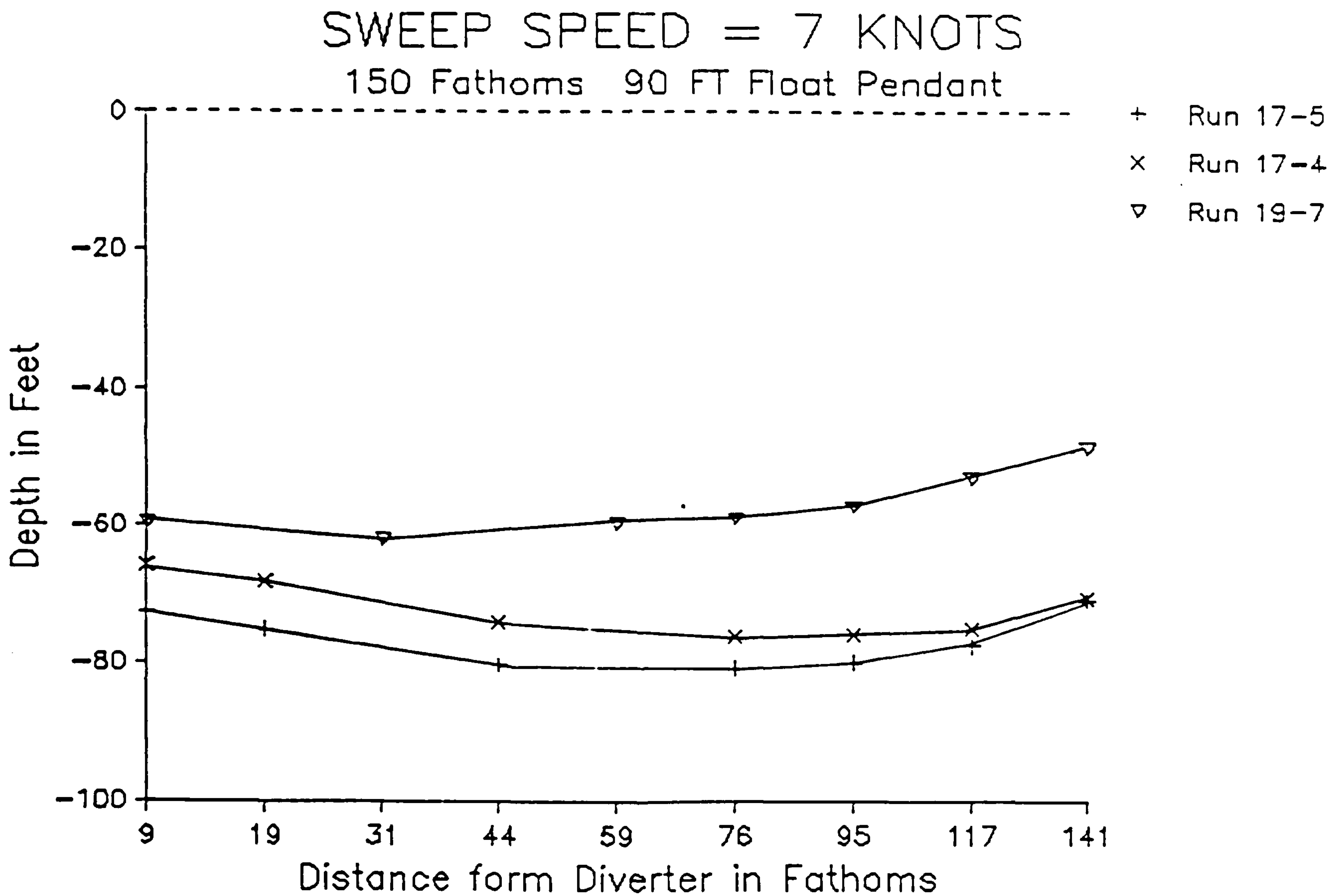

SWEEP SPEED = 7 KNOTS
150 Fathoms 90 FT Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
31
44
59
76
95
117
141
Distance form Diverter in Fathoms
Run 17-5
Run 17-4
Run 19-7

FIGURE 6.6

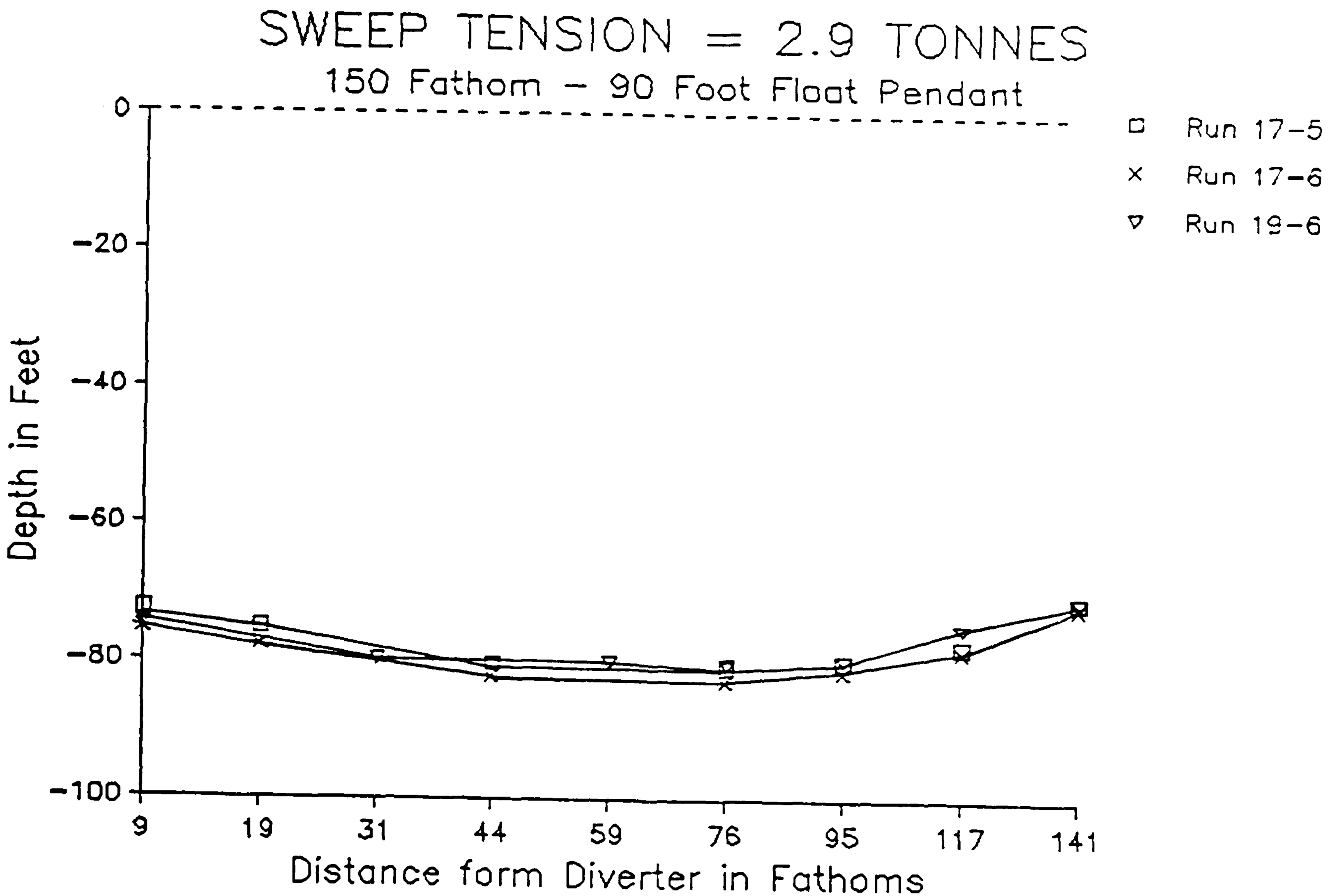
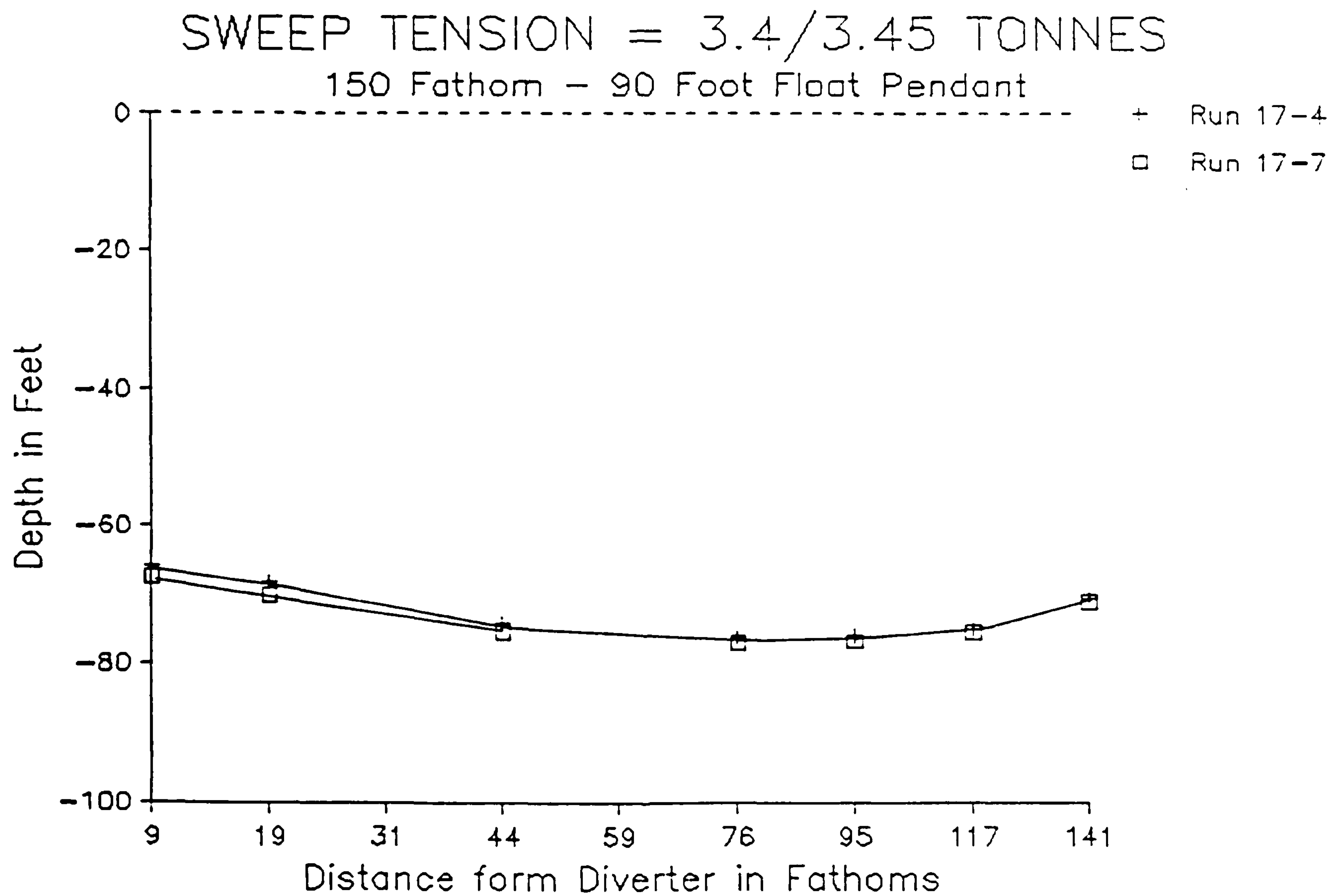

SWEEP TENSION = 2.9 TONNES
150 Fathom - 90 Foot Float Pendant
Run 17-5
Run 17-6
Run 19-6
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
31
44
59
76
95
117
141
Distance form Diverter in Fathoms

FIGURE 6.7


SWEEP TENSION = 3.4/3.45 TONNES
150 Fathom – 90 Foot Float Pendant
Run 17–4
Run 17–7
0
–20
–40
–60
–80
–100
Depth in Feet
9
19
31
44
59
76
95
117
141
Distance form Diverter in Fathoms

Figures 6.8, 6.9, and 6.10 are profiles of the 200-fathom, 60-foot float pendant sweep configuration. In Figure 6.8, run 21-1 was the control run. Run 21-3 was towed at the same speed and run 21-2 was towed at the same tension. For this set of runs, tension profiles were more repeatable than the speed runs. However, not all the tension runs showed such repeatability. Figure 6.9 shows sweep profiles for five runs that were towed at the same tension. Although not extreme, the diversity in the profile must be noted. (The depth recorder at the 9 fathom mark malfunctioned and new points were estimated for the graphs.) Figure 6.10 shows two sweep profiles towed by speed with the highest tension run at the shallowest depth.

Figures 6.11 through 6.14 are profiles of the 150-fathom, 60-foot float pendant sweep configuration. The 2.9-tonne tension profiles (Figure 6.11) and the 6.0-knot profiles (Figure 6.12) were almost identical with minimal uncertainty in the sweep depth. Both the 3.3-tonne tension profiles and the 8.2-knot profiles (Figures 6.13 and 6.14) showed less repeatability, with the 8.2-knot speed run having the greatest deviation in sweep path. There were two more profiles in the 3.3-tonne sweeps making direct comparison difficult.

There were no failures, major or minor, of any WSME component. The system was operated for over 40 hours during the test, 6 hours being the maximum period of continuous operation. WSME tension readings compared to the NCSC calibrated tensiometer within ∓ 200 pounds throughout the test. The tension beam was easy to install and could be done without violating fantail safety procedures. System maintenance was minimal requiring placing the calibration bar in the tension beam and stowing them at the end of each test day.

FIGURE 6.8

SPEED AND TENSION COMPARISON

200 Fathom — 60 Foot Float Pendant

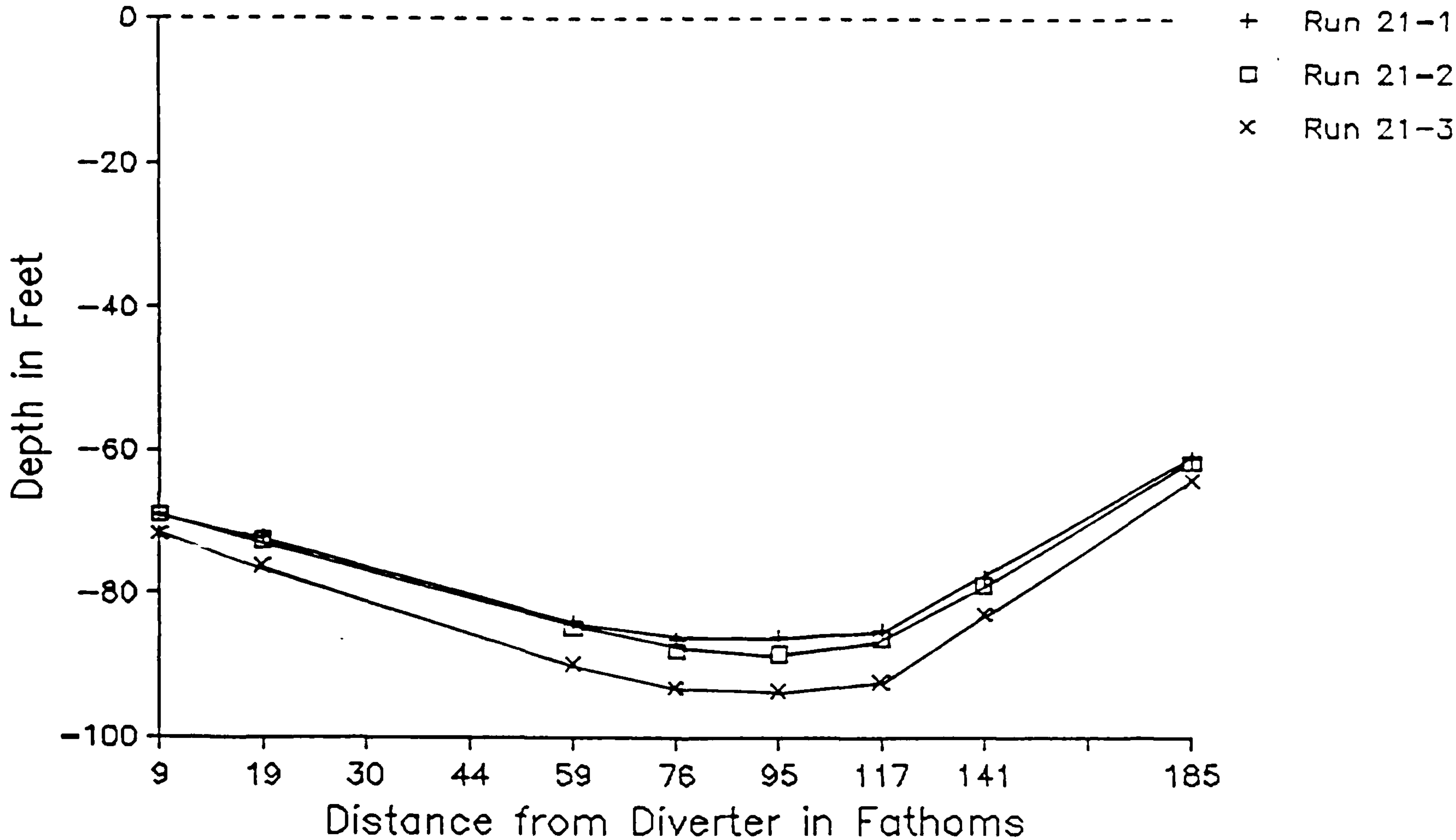


FIGURE 6.9

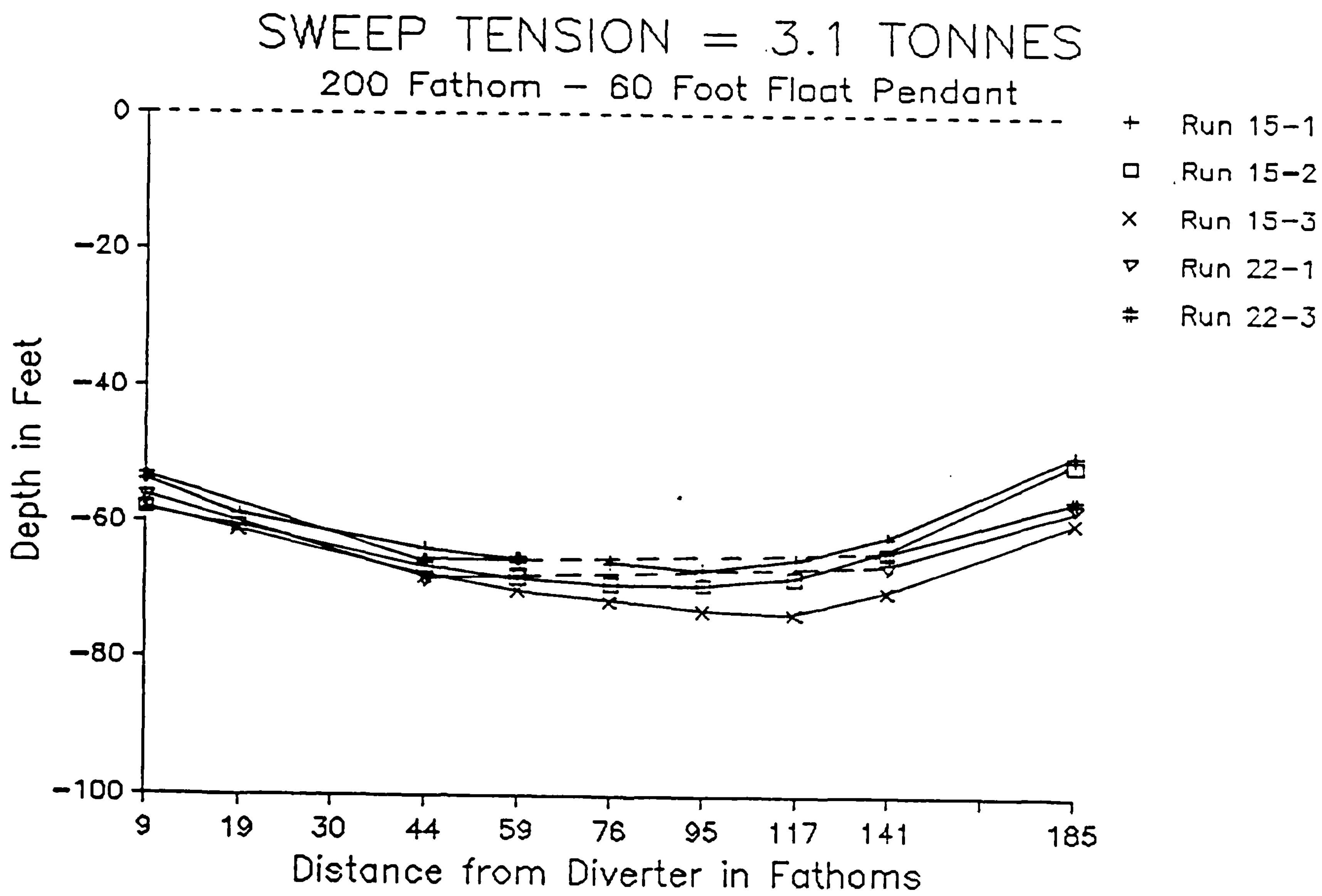

SWEEP TENSION = 3.1 TONNES
200 Fathom - 60 Foot Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
30
44
59
76
95
117
141
185
Distance from Diverter in Fathoms
Run 15-1
Run 15-2
Run 15-3
Run 22-1
Run 22-3

FIGURE 6.10

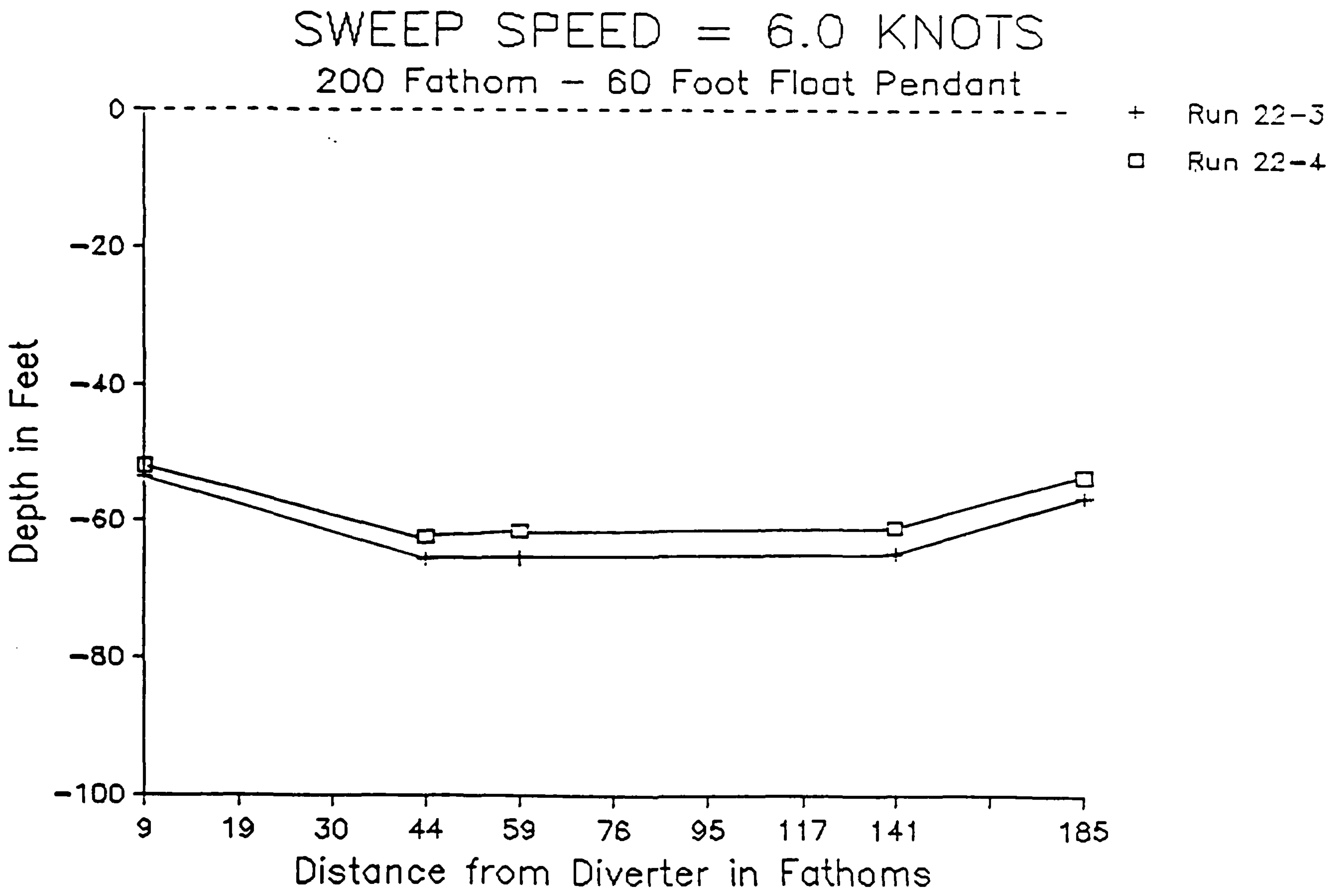
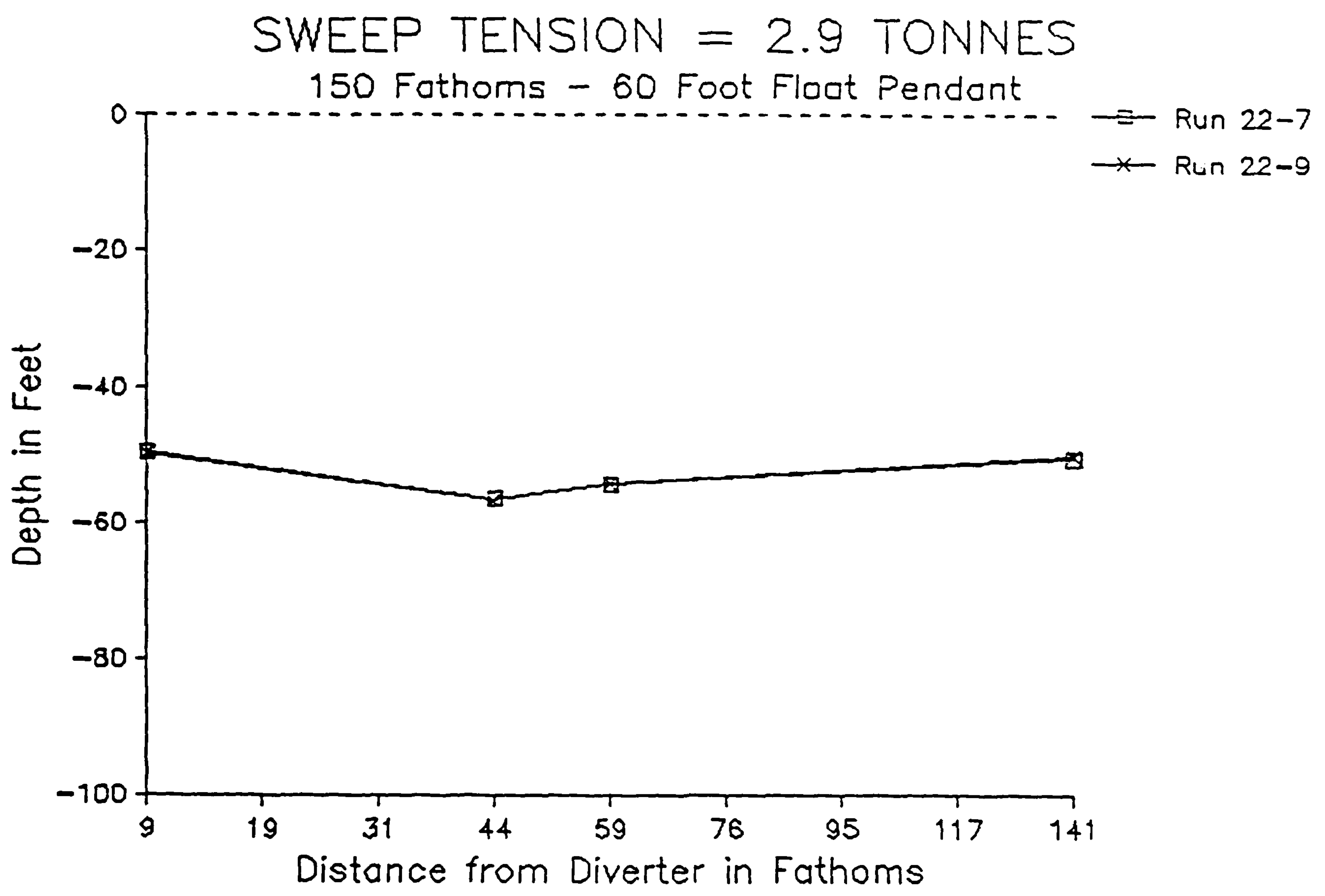

SWEEP SPEED = 6.0 KNOTS
200 Fathom – 60 Foot Float Pendant
Depth in Feet
0
−20
−40
−60
−80
−100
9
19
30
44
59
76
95
117
141
185
Distance from Diverter in Fathoms
+ Run 22–3
□ Run 22–4

FIGURE 6.11



SWEEP TENSION = 2.9 TONNES
150 Fathoms - 60 Foot Float Pendant
Run 22-7
Run 22-9
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
31
44
59
76
95
117
141
Distance from Diverter in Fathoms

FIGURE 6.12

Constant Speed Sweeps: 6.0/6.1 Knots

150 Fathoms - 60 Foot Float Pendant

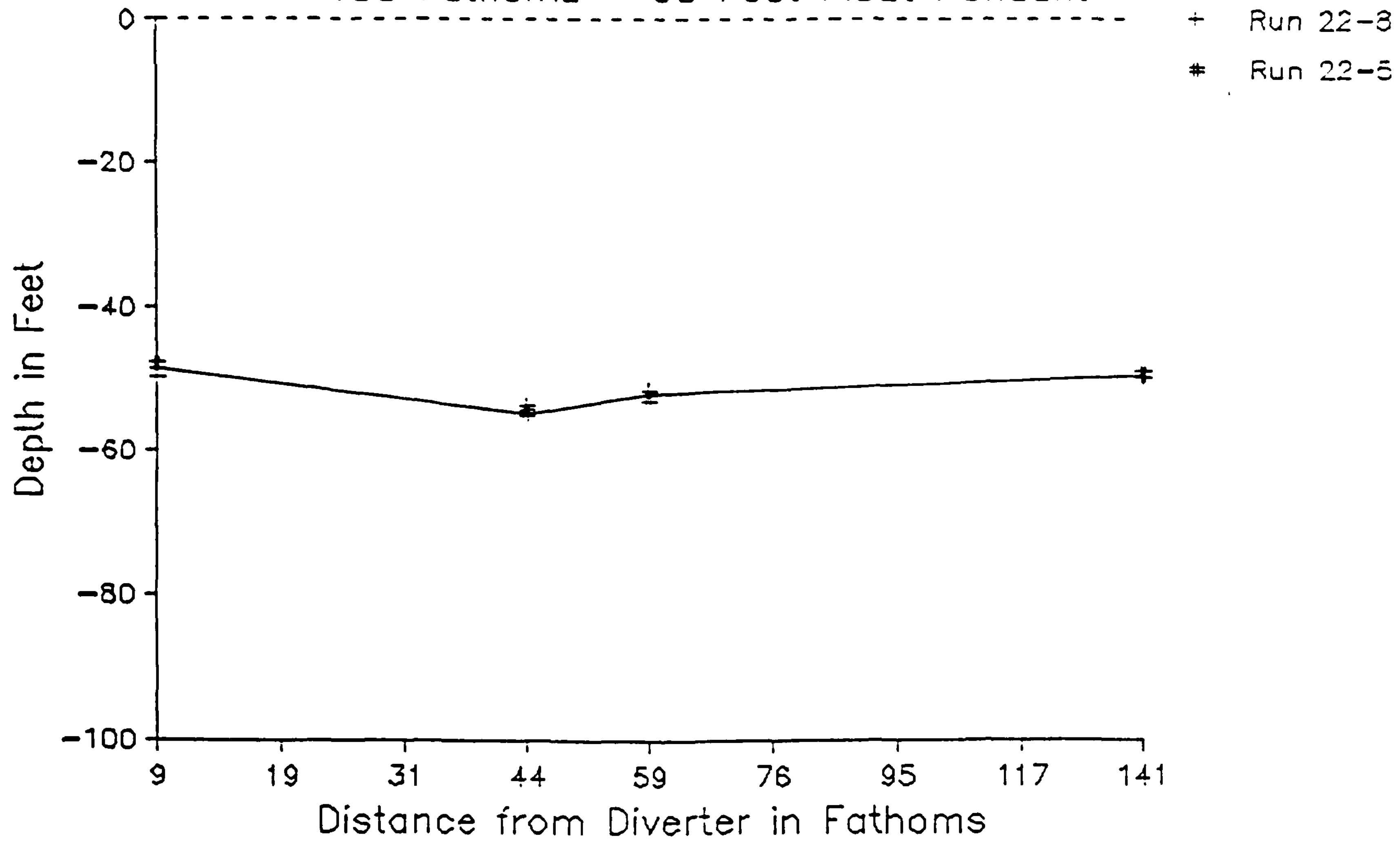


FIGURE 6.13

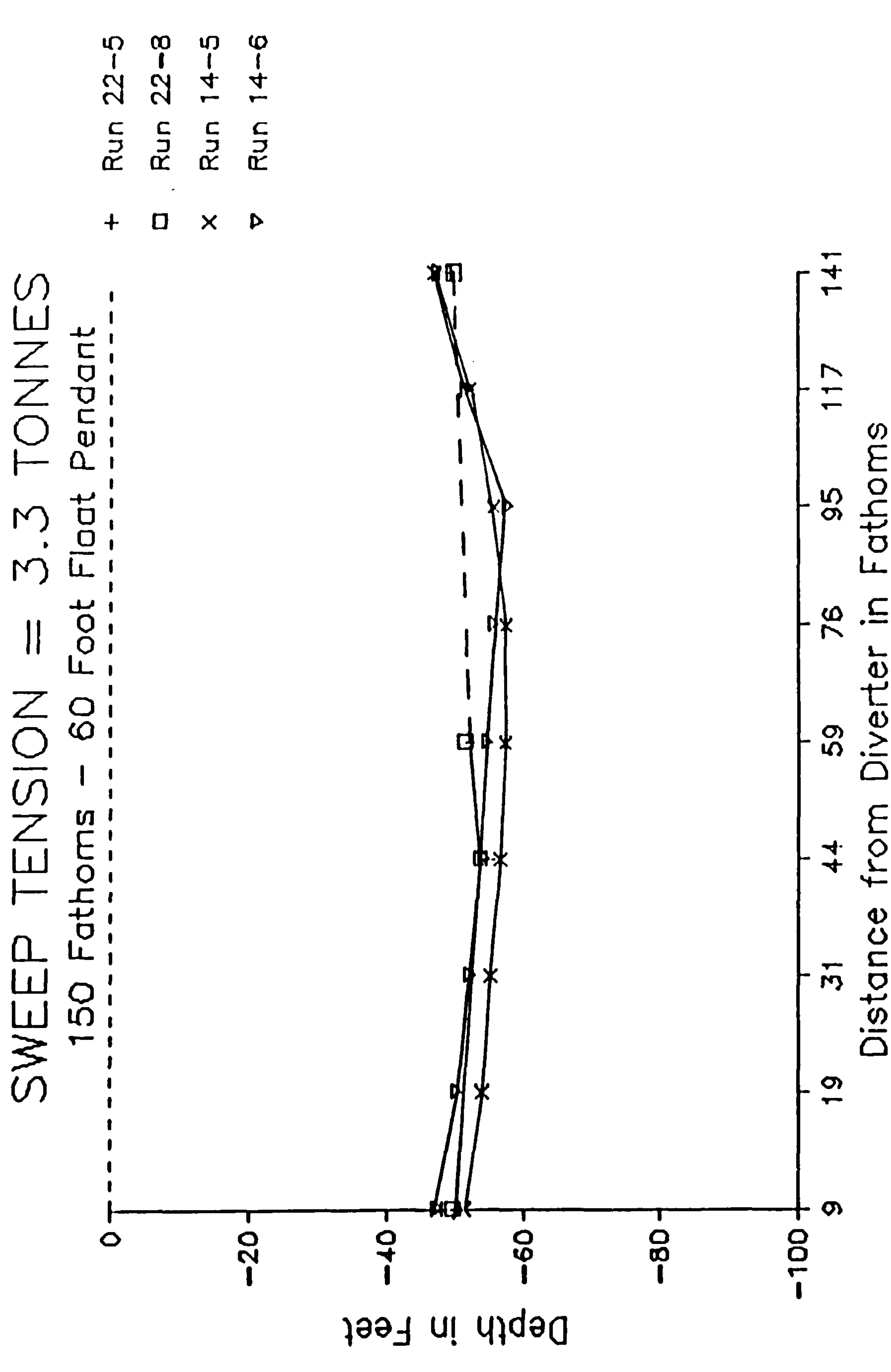
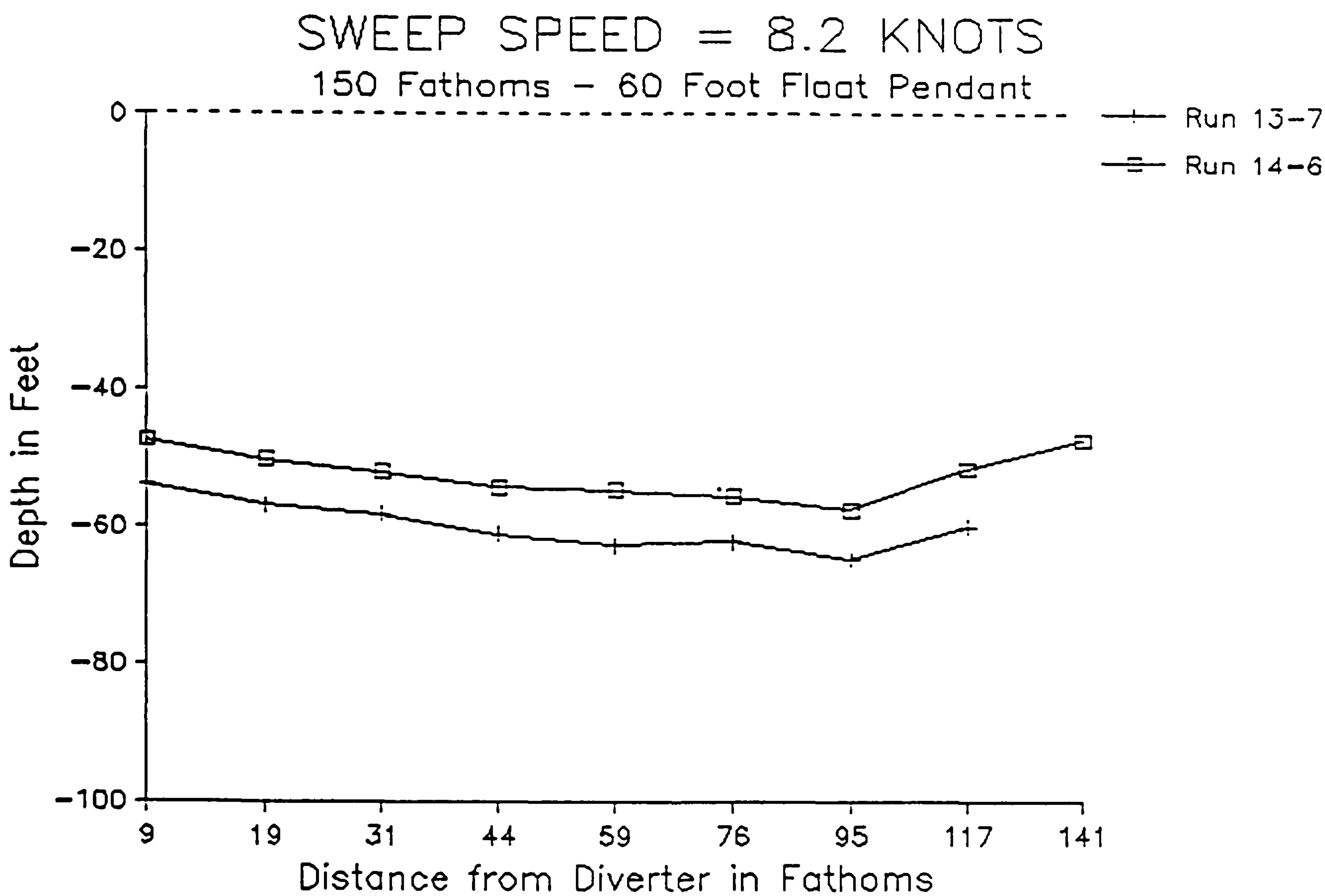

SWEEP TENSION = 3.3 TONNES
150 Fathoms - 60 Foot Float Pendant
+ Run 22-5
□ Run 22-8
× Run 14-5
▽ Run 14-6
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
31
44
59
76
95
117
141
Distance from Diverter in Fathoms

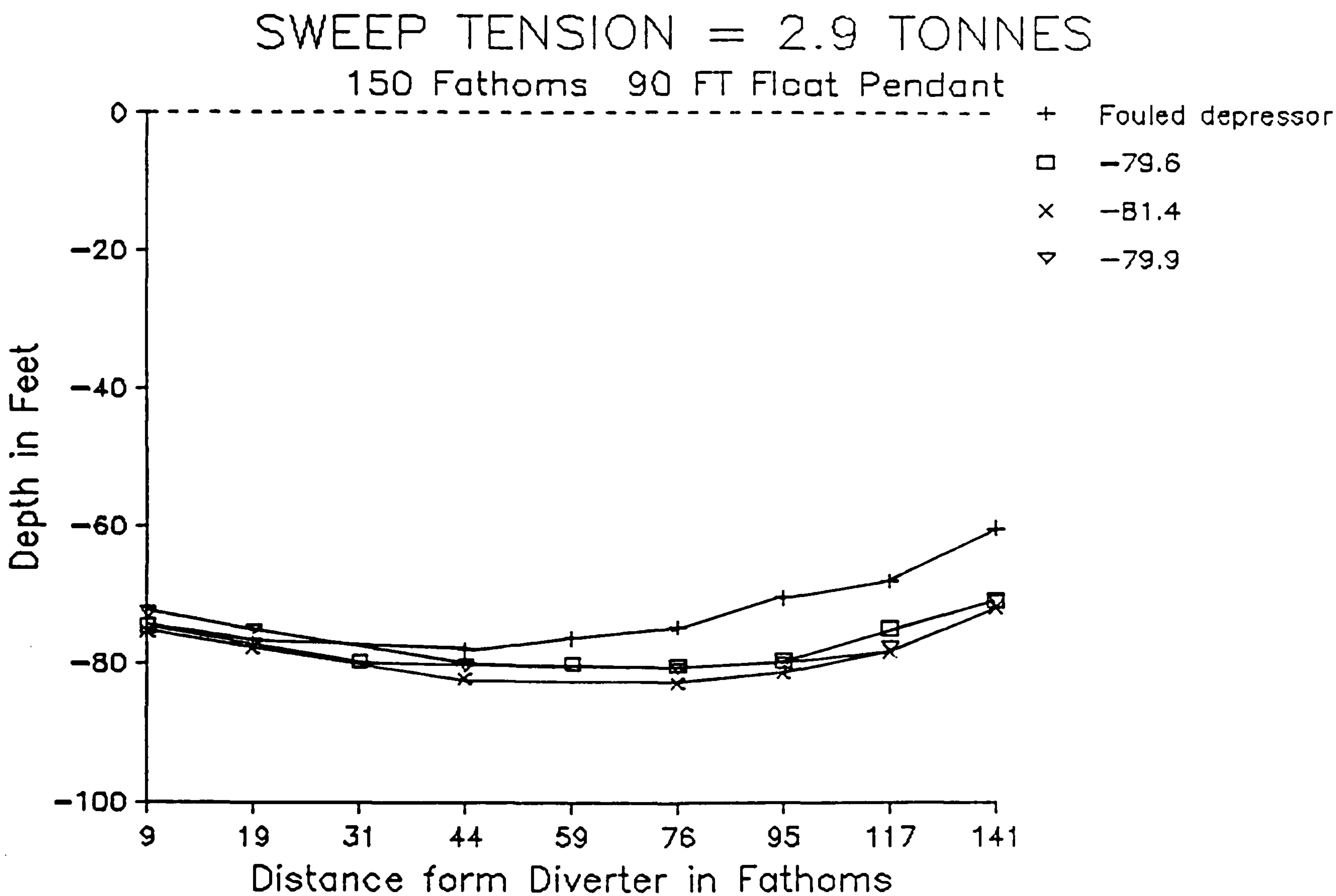
FIGURE 6.14



SWEEP SPEED = 8.2 KNOTS
150 Fathoms - 60 Foot Float Pendant
Run 13-7
Run 14-6
0
-20
-40
-60
-80
-100
Depth in Feet
9
19
31
44
59
76
95
117
141
Distance from Diverter in Fathoms

A major problem with using WSME with Oropesa type sweeps is that it only provides tension readings of one sweep wire. By monitoring tensions in both the outboard and inboard sweep wire during a turn, the ship can adequately judge if the turn is too sharp. Without this guide, the ship will have to make wider turns to prevent fouling the gear. In addition, monitoring the tension in only one sweep wire makes it difficult to assess the problems involving the other wires. An example of this problem can be seen in Figure 6.15. The depressor had fouled resulting in an altered sweep profile. This problem was not observed until the depth recorder data had been analyzed. As a result, the NCSC electronic tensiometer was closely monitored throughout the remainder of the test. Since the NCSC tensiometer monitors all three sweep wires, depressor problems could be noted and were corrected as they occurred.

FIGURE 6.15



SWEEP TENSION = 2.9 TONNES
150 Fathoms 90 FT Float Pendant
Depth in Feet
0
-20
-40
-60
-80
-100
9
19
31
44
59
76
95
117
141
Distance form Diverter in Fathoms
Fouled depressor
-79.6
-81.4
-79.9

7.0 CONCLUSIONS

1. The uncertainty in sweep wire profile is greater when ship speed rather than sweep wire tension is used as a towing guide. During the test period, the maximum depth uncertainty along the sweep wire seen for sweeps towed by speed was 130 square yards; and for tension, the maximum value was 45 square yards.

2. Although sweeping by tension produces more repeatable profiles than sweeping by speed, profile variations are not eliminated.

3. WSME does not measure and display sufficient information for "O" type sweeping on MSOs. Monitoring the tension of only one wire is unacceptable in that this limits ship manueverability and does not provide information of the other towed wires.

4. Speed adjustments may not be fine enough on MSOs to maintain target tension in the sweep wire. Making the finest speed change possible often resulted in tension changes of 600 pounds.

5. When using tension as a towing guide, sensitivity to sweep wire problems is lessened. For example, when towing by speed, severe tension changes indicate fouled sweep wire or other problems with the gear. These tension changes are less likely to be observed when sweeping by tension.

5. WSME showed good reliability during the test period. The system was easy to use and met all safety requirements during installation and operation.

8.0 RECOMMENDATIONS

1. To minimize sweep depth uncertainty, MSOs should use tension rather than speed as a towing guide for Oropesa type mechanical sweep systems.

2. When towing by tension, drastic speed changes should be noted and peak tensions monitored on a regular basis. Both these factors are indicative of sweep conditions.

3. WSME should not replace existing tensiometers on MSOs. Although a reliable and safe system, it is less capable than the existing/planned MSO tensiometers because:

a. WSME is not capable of measuring tension of all three sweep/depressor wires.

b. WSME does not display or hold overall peak tensions. (The "peak" displayed by WSME is the peak of the values used to calculate the mean tension. The "peak" is updated every time the mean is updated; every 3 seconds during this test.)

4. Future testing of WSME should be limited to variable depth sweeps such as IDMS. Towing by tension is an acceptable concept, however, this concept with respect to WSME cannot be tested using float pendants to limit sweep depth.

APPENDIX A

DETAILED TEST EVENTS

APPENDIX A

DETAILED TEST EVENTS

Single Oropesa ("O") sweeps were deployed using size 1 mechanical sweep gear. Eight cutters on the 150-fathom sweep (9 on the 200-fathom sweep) were replaced with depth recorders set to collect depth data every 30 seconds. Upon completion of streaming, the WSME tension beam was connected to the starboard sweep wire.

During the first day of testing, WSME and the support test equipment were checked out and a run to establish depressor wire scope for the 150-fathom, 60-foot float pendant.

During the second day of testing, seven runs were completed with a 150-fathom scope, 60-foot float pendant, 10 and 13 fathom depressor scope. The objectives of these runs were to establish the correct depressor wire scope, and determine which tension resulted in a flat profile.

Six runs were completed on the third day of testing. The first four runs were 200-fathom, 60-foot float pendant, 17 and 19 fathom depressor scope. The first of these runs was at maximum ship speed (8 knots) which resulted in a tension of 3.5 tonnes. The second run's tension was reduced to 3.0 tonnes. The third and fourth runs were repeats of the first two except for the depressor scope, which was increased from 17 to 19 fathoms. By obtaining a variety of data points, it was possible to estimate the target tension and depressor scope. Runs five and six were 150-fathom, 13-fathom depressor scope towed at 3.3 tonnes. Run 14-5 was targeted as a repeat of run 13-7 with a tension of 3.5; however, it could not be maintained. Run 14-6 was also a repeat of run 13-7 but with a successful targeted speed of 8.2 knots.

On day four, the test series run was conducted with the 200-fathom, 17-fathom depressor scope configuration. The first run, run 15-1, was targeted for 3.0 tonnes, however, the actual tension was 3.1. This run was repeated in an effort to achieve the desired tension, but again it was not possible. A course change was made and the next two runs were conducted. The first of these runs, run 15-3, was set to the tension of run 15-1 (3.1 tonnes) and also ended up being the same speed. Run 15-4 had a target tension of 3.3 tonnes but actual tensions varied from 3.1 to 3.5. Another course change was made to keep the ship in the operating area and the ship's speed was increased to try and reach the 3.3-tonne target tension. This run's tension varied from 3.4 to 3.8. At this point it was realized the speed adjustment of the craft was too coarse making it difficult to maintain a constant tension for a 20-minute period.

The fifth and part of the sixth day of testing were used to establish depressor wire scope for 150- and 200-fathom sweeps with a 90-foot float pendant. During these runs it was noted that the ship's speed would decrease over the 30-minute runs even though the heading and pitch remain constant. There had been two engine casualties previously during the test and although they had been repaired, the performance of the engines was deficient.

The last four runs of day 6 were tension/speed runs for the 150-fathom, 90-foot float pendant configuration. The first run was at 7 knots and 3.4 tonnes. A course change was made and a run at the target speed of 7 knots was completed. Run 17-6 had a target tension of 3.5 which could not be achieved while on that heading. The target tension was reduced to 2.8 for a comparison with run 16-4 but the achieved tension was 2.9 with a speed of 6.7 knots. A comparison tension run to run 17-4 was set up in a new direction with an achieved tension of 3.45.

The 150-fathom/90-foot float pendant runs were repeated the following day, one run at 2.9 tonnes and the second at 3.5 tonnes (runs 19-6 and 19-7). Five 200-fathom/90-foot float pendant runs were conducted. The first run was at 6 knots with a target tension of 3.6 tonnes. A course change was made with run 19-2 targeted for 3.6 tonnes (3.5 was achieved) and run 19-3 targeted for 6 knots. The fourth run of this series was on a different heading with a target and achieved tension of 3.5 tonnes and a speed of 6.8 knots. The fifth run of the series was a speed run targeted for 6.0 knots; 5.8 was achieved.

The first run of the eighth test day, run 20-1, was a repeat of the 200-fathom/90-foot float pendant run at 6 knots of the previous day. Run 20-2 was a repeat of 20-1. A course change was made and run 20-3 was conducted with a target and achieved tension of 3.2 tonnes. Run 20-4 was a speed run in the same direction with an achieved speed of 6.0 knots. After the completion of run 4, the sweep wire scope was reduced to 150 fathoms. Runs 20-5 and 20-6 were targeted for tensions of 3.0 but this was not achieved (3.2 and 2.9 tonnes were the mean values for these runs). Run 20-7 was aborted because of high tensions on the depressor wire. Run 20-8 was a tension repeat of run 20-6 successfully maintaining a tension of 2.9 tonnes.

On the ninth day of testing, there was an engine problem and speeds were limited to 4.2 knots. Three 200-fathom, 60-foot float pendant runs were conducted. Run 21-1 was a control run with a speed of 4 knots and a tension of 2.2 tonnes. Run 21-1 was a tension at 2.2 and run 21-3 had a targeted and achieved speed of 4.0 knots.

Nine runs were attempted on the 10th test day; 8 were completed. The first four runs were 200-fathom, 60-foot float pendant configurations. Attempts at both targeted tension and speed runs were unsuccessful, however, the first and third runs were at 3.1 tonnes and the third and fourth runs were at 6.0 knots.

The last four runs were with a 150-fathom, 60-foot float pendant. Run 22-5 was at the same tension (3.1 tonnes) as run 22-8. Runs 22-7 and 22-9 were towed at 2.9 tonnes. (Run 22-6 was aborted because of an engine failure.)